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ON MATERIAL REPRESENTATIONS OF DEDUCTIVE PROCESSES

THE difficulty of describing, representing, classifying, mental attitudes without having recourse to metaphors of a "physical" character has long since claimed the attention of philosophers.

They have not failed to draw from it, according to their special preferences, the most opposed and disparate conclusions.

Thus, for example, while Locke ("Essay," III., 2) sees in it a proof and a verification of his thesis "that all our notions originate in sense impressions," Leibniz, on the other hand ("Nouveaux Essais," III., 1), seeks to draw from it conclusions favorable to the doctrine of the "primordiality" of space intuitions (intuitions of direction, distance, motion, etc.).

The advantages and inconveniences inherent in the use of these metaphors offer, however, a field of research which may be described as almost unexplored. The recent publication of a volume calling attention to the importance of this subject has afforded me an opportunity to express some observations on it.[1]

To one who proposes to make a systematic examination of the employment of physical metaphors as a means of representing mental facts two roads are open. As in hydrodynamics, when we wish to observe the motion of a liquid in a tube, we may consider a definite section of the tube, determining the velocity and direction of the various portions of liquid which pass successively through it, or we may, conversely, follow a given portion of the liquid, determining the various velocities and directions which it assumes in crossing the successive sections; thus here we may start from the consideration of a definite image, observing what are the various mental operations which it may be chosen to illustrate, or we may, conversely, start from a definite mental operation, and pass in review the different images by which it can be represented.

For any one having, besides a purely theoretical interest in analyzing the mechanism of mental processes, the comparatively practical intent of drawing, from such an analysis, some indications of the means of regulating the play of mental activities, researches of this second kind are found to be more important than those of the first. It is to one of them—that is, to the analysis of the various physical representations of the deductive process—that I propose here to direct the attention of the reader.

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[1] In *Leonardo*, February, 1905, reviewing Lady Welby's book, "What is Meaning?" (Macmillan, 1903).

The various types of images adopted to express the fact that a given affirmation may be *deduced* from another can be roughly classified under the following headings:

I. Those in which recourse is had to the conception of ''upholding'' or ''supporting,'' as, for instance, when it is said that given conclusions are ''based'' upon, or ''founded'' upon, given premises, or that they ''depend'' upon (or are ''attached'' to) them. It is thus that we speak of the ''foundations'' of geometry, the ''basis'' of morals, etc.

II. The metaphors of ''ascending'' or ''descending,'' as when we speak of consequences which ''descend'' from or may be ''traced up'' to certain principles, or when we compare the ''course'' or running of an argument to that of a river, and speak of propositions which ''derive'' from, ''flow'' from, ''spring'' from, ''emanate'' from, the premises from which they are ''drawn.''

In this same group we may collect also the metaphors of a biological character, in which consequences are regarded as ''generated'' from premises, and the premises as ''roots,'' ''germs,'' etc., of the corresponding conclusions.

III. The metaphors referring to the relation of ''containing'' or ''including.'' These may be subdivided into two groups, according as the conclusion is regarded as ''contained'' in the premises, or the latter as ''contained'' in the conclusion. In the first case the premises are conceived as ''implying'' (*implicare*), in the second as ''explaining'' (*explicare*), the conclusion which is deduced from them. The deduction is thus often looked upon as an ''analysis'' or a ''reduction,'' that is, as an operation analogous to the work of a chemist who decomposes a body into its elements.

A characteristic of the first two groups of metaphors, that is, of those by which deduction is referred to as a ''supporting'' or ''a drawing'' one assertion by or from another, consists in their lending themselves to the embodiment of one of the most radical objections that can be raised against deduction as a means of proof and ascertainment of truth. It is the objection frequently referred to by Leibniz as ''difficultas Paschaliana de resolutione continuata,'' although Pascal was certainly not the first to raise it. (It has never ceased to be enunciated, under the most different forms, ever since the conception of deduction as a special kind of reasoning first occurred to the mind of the Greek sophists and rhetors.) It consists in observing that all processes in which an attempt is made to prove some assertion by deducing it from another must be based, in the ultimate analysis, upon assertions which, in their turn, can not be deduced from any other, upon assertions, that is, which can not be proved without recourse being had to some other process (induction, intuition, etc.) whose validity deduction can not guarantee; and that, therefore, the certainty which belongs to the conclusions of deductive reasoning can not in any way be held superior to that which we are disposed to attribute to assertions not to be justified by deduction. Deduction, therefore, far from being regarded as the type of mental process conducive to "sure" conclusions, should be looked upon only as a means of causing a greater number of assertions to participate in the certainty, which, quite independently of deductive reasoning, *some* of our beliefs *must* already possess. According to that conception of deductive reasoning, a man who only deduces could not be regarded as a *producer,* but simply as a *distributor* of "certainties"—a retail dealer in a commodity which his activity in no way contributes to bring about.

It is here worth noticing that whatever opinion we may entertain as to the existence or otherwise of premises which have no need of proof, it does not prejudice the question of the greater or less value of deduction, even if considered only as a means of ascertainment of our knowledge. Notwithstanding contrary suggestions, arising from images representing premises as "pillars" or "pegs" by which conclusions are "upheld," the advantages we derive, in regard to the certainty of our opinions, by recognizing that one proposition is deducible from another does not consist exclusively in the participation so acquired by the former in the greater certainty which the latter enjoys. The opposite case, in which the truth or certainty of conclusions, deducible from given premises, is apt to increase and consolidate the certainty of the premises themselves, is no less frequent nor less important to be kept in view. The two advantages are very rarely found separated, in so far as there is hardly any branch of knowledge in which the premises are so indubitably secure that they can not receive further plausibility from their leading to conclusions immediately verifiable, while there is no assertion (except, perhaps, those relating to the so-called direct testimonials of our consciousness, in so far as they exclude all element of prevision) whose degree of credibility may not be, in some measure, increased by its agreeing with the consequences of some previously accepted belief.

The relation between premises and conclusion of a piece of deductive reasoning would not, therefore, be correctly described by saying that the latter is "supported" by the former, unless the common image of one object "supported by another" be substituted by the more general and more scientifically precise one of bodies which are "attracting each other," and which, when in contact, do support each other by reciprocal pressure. Of a pebble resting on a rock it is equally correct to say that the whole earth does support it as to say that the whole earth is supported by it.

Analogous observations may be applied to the image which represents conclusions as attached to the premises by means of a "thread" (or "chain") of reasoning. With this image also, in fact, the diffusion and communication of certainty are ordinarily conceived as acting *in one single direction*, *i. e.*, from the premises to the conclusions: no notice is taken of the fact that deduction may also act in the opposite direction, in the same way as the rope with which Alpine climbers fasten themselves in a dangerous ascent does. This rope is, in fact, a guarantee of safety to the last as well as to the first, or to any other among those who are bound by it.

Deductive processes in which the certainty of the assertions, which are taken as starting-point, is greater than the certainty of the conclusions to which they lead, are usually termed "demonstrations"; while those in which the contrary occurs, that is, those where given facts are attached to disputable premises, are usually described as "explanations." But the latter as much as the former are "deductive" processes, and in both cases there is the same need of all the apparatus and all the aids by which the operation of deduction may be made easier and more reliable.

To have taken knowledge of this—to have recognized that, even when the premises of a piece of deductive reasoning are less certain than the consequences drawn for them, it continues to be, nevertheless, important to proceed with rigor, with coherence, and with precision—is perhaps to be considered as one of the chief characteristics of the attitude of modern scientific thought as opposed to the one typically represented by Greek speculation. One is tempted to attribute to that circumstance the fact that the latter, while it showed the greatest constructive audacity in those fields in which, as in geometry, the firmness of the starting points (*axioms*) reached its highest standard, on the other hand, in fields, such as physics and mechanics, where this was not the case, it hardly succeeded in raising itself (except in astronomy) above a rough empiricism, as if it had been almost incapable of discerning any connection between facts besides those which offered themselves spontaneously to a passive observer not availing himself of any coordinating or selective preconception.

A corresponding tendency to depress and diminish the importance of deduction as compared with other processes of reasoning or of research is also countenanced by the metaphors of the third group above defined, *i. e.*, by the metaphors representing deduction as a process of "extracting" from premises that which is already "contained" in them.

To say that the conclusions of a piece of deductive reasoning are to be found, even "implicity," "contained" in the premises, differs, indeed, very little from saying that they not only assert *nothing more,* but even assert *something less,* than what is already asserted in the premises themselves.

We know the manner in which the first great theorist of deduction, Aristotle, tried to carry this objection. He had recourse to another comparison, based upon his favorite contrast between form and matter. That is, he compared the work of one who deduces to that of the sculptor, who, by taking from a mass some of its parts, obtains something of greater value than the mass itself. If, however, instead of a statue he had spoken of an instrument or a weapon—say, of a key or of a dagger—also constructed by removing, from a given place in the raw material, certain parts whose presence would be an obstacle to the end which the instrument or the weapon was to serve, the comparison would have been also adapted to illustrate the power of deduction as an organ for the application of knowledge to the end of acquiring more of it.

In a certain sense the contrast between the process of deduction and that, purely or chiefly passive, of observation, contemplation, registration of the data of experience or of intuition, might even be compared to that between the operations of conscription, intended to secure the service of that part of a population which is fit to bear arms, and the operations of taking the census, directed only to the recognition and description of the state of population in a given country and time.

But, as we have already suggested, there is another direction, exactly opposite to the preceding, in which images referring to the relation of "containing" are capable of being employed as representing the relation subsisting between premises and conclusion in a piece of deductive reasoning. Premises, from which a given conclusion is deduced, may be regarded, not as "including" or "implying," the conclusion itself, but, on the contrary, as the more "simple" elements *of* which it is "composed" or *into* which it may be "resolved." It is the favorite image of Plato, when in the "Theætetus" (200–208) he compares the fundamental premises of science to the letters of the alphabet (στοιχεία) from the combinations of which result syllables, words, phrases. And it was natural, as the very title of the works of Euclid shows, that this imagery should find special favor among geometricians, since no other is more fitted for refuting the objection of which we have spoken. In the light, indeed, of this comparison such an objection appears little less absurd than an attempt to dispute the genius or originality of a poet or of a musician by observing that all the words or notes used by him are registered in our dictionary, or in our gamut.

To this remarkable advantage which the images of deduction that we have called "chemical" offer in comparison with the other methods of representation before examined, there is, however, a drawback, consisting in their tendency to give rise to a false (too absolute) view of the contrast between simple and complex truths, and to present as the supreme ideal of scientific research the determination of propositions absolutely primordial, non-decomposable, atomic, capable of generating all others by their various aggregations.

This idea is found under its most determined form by Leibniz, in the comparison he establishes of truths with numerals, each of which, if it is not a prime number itself, is always apt to be decomposed, and in manner only, into a product of prime factors.

By such a metaphor as that, we are inevitably induced to lose sight of the fact that the question, whether a given proposition can be demonstrated or not, can only have a meaning if we determine what are the other propositions whose employment is to be permitted in the demonstration required.

When we speak of deduction as an "*analysis*" we must not forget that the properties of such an analysis are very unlike those of chemical analysis. In the latter, indeed, it could never happen, for example, that, among the "elements" out of which a given body is composed, some be found of which the body in question could also be considered as one of the "elements."

There is, in this last respect, a complete analogy between the process of deduction and that of definition. The latter also is, indeed, frequently represented as a process of decomposition or analysis of "ideas," or "notions" (or of the meanings of words), into more simple or more general notions or ideas.

Both the relation of a complex notion to the more "elementary" notions it implies, and the converse relation of the group of individuals, coming under a given complex notion, to the other groups coming under the more "simple" notions by which the complex one is defined, are found in Aristotle[2] represented by the images of ''*containing*'' and of ''being *contained.*''

Metaphors of the second group above defined, that is, those by which the passing from the premises to the conclusion is qualified as a ''descent,'' and the seeking for the premises of a conclusion as an ''ascent,'' or a ''remounting,'' or ''going up,'' have this in common with those of the type before examined, that they are applicable to the case of deduction as well as to that of definition. Defining also is, indeed, often described as a ''tracing up'' from particular intuitions to the more general conceptions ''*under*'' which they are comprised. So in the so-called ''tree of Porphyry'' the successive ramifications from the trunk represent notions ever more definitely determined, and which are obtained by the gradual introduction of successive specifications and qualifications, in the more general and comprehensive of all classes, *i. e.*, in the class constituted by all ''existing things.''

An inconvenience, not to be overlooked, which arises from this twofold employment of the metaphors of the last two groups considered—that is, from their being employed at the same time to express the relation between premises and conclusion and that between a notion and the more general notions implied by it—consists in this, that both tend to give plausibility to the conception of deduction as ''a passing from the general to the particular,'' and to make us look upon the greater generality of premises, as compared with conclusions, as an essential characteristic of deductive reasoning. It is difficult to find a different explanation for this mode of conceiving deduction having found favor, in spite of the frequency with which demonstrative processes of quite opposite character (in which, that is, conclusions comprise some of the premises as particular cases) present themselves in the most deductive of sciences,—mathematics.

So far as regards the images which represent deduction as an ''*ascent*'' to principles, the aforesaid inconvenience is, however, broadly compensated for by the correspondence which they establish between the condition of one who places himself at the point of view of the premises of a deductive process and that of one who, observing a panorama from a height, is in a position to perceive at a glance, between the various parts and regions which are before him, relations which would escape the notice of or be discovered with difficulty by one who was stationed lower down.

An analogous conception is also expressed by the phrases which characterize the process of demonstration or of explanation as a process of "throwing light," inasmuch as the presence of light has the effect of "economizing experiences" by rendering at once possible the recognition of the respective positions of objects: positions which in its absence could only be determined by subjecting oneself to the shocks and collisions inevitably ensuing from attempts to take direct cognizance of their situation.

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[2] *τὰ εἲδη τοῦ γένους φασὶν εἶναι μορία · · · τὸ γένος τοῦ εἴδους καὶ μέρος λέγεται.* "Metaphysics," IV., 25.

Compared with this last metaphor, however, the one first considered, that of "ascent," presents the additional advantage of suggesting, besides the conception of seeing, that of command or power, as when we speak of a "commanding view" or of a height which "dominates" a given region.

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DISCUSSION

STRUCTURE AND GROWTH OF THE MIND

THE publisher of this JOURNAL has been good enough to send me the number of January 16, marking a review of my book on the "Structure and Growth of the Mind"; but it is now March, and the Editor can not welcome a three-monthly discussion in his fortnightly pages. Still all three topics on which the book is challenged fit well the full title of the JOURNAL; they are the brain-and-mind question, the mind-and-experience question, and the subject-experience question. And since my treatment of them, as Dr. Perry presents it, is obviously not worth discussing, and hardly needs repudiating, I may confine myself more to the topics themselves. The only thing about which I should like to complain is his complaint that "there is no contour or difference of emphases, so that reading the book is like swimming under water with never a chance to come up and look about." Repelled by "the undeniable dreariness and obscurity of the preface,"—a couple of pages of print as wide as pica, giving four reasons for not confining psychology to "structural psychology,"—he would not risk the five and twenty pages of contour lines in brevier that follow them. They are, however, a summary of the whole, paragraph by paragraph, which I put at the beginning instead of along the margin, in order that the whole should be read as an exposition of the logic of psychology, and, in particular, an exposition of the theory of the mind in psychology. It is not the mere truth of such a theory that can be in question, but the use of it; hence it is only to be expounded by setting it to work, and not by showing it to hold here, there, and everywhere, like a Spencerian formula with its "Here we are